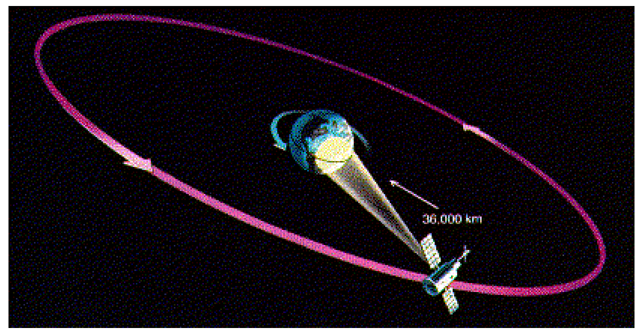
Satellite Antenna Fundamentals

The following fundamentals are presented to help the lay person understand the basics of satellite downlink and reception and why certain adjustments and settings are so critical to close the satellite link. Closing the link simply refers to establishing a communication path between the satellite and the earth station or satellite dish/antenna.

Most communication satellites reside in a belt above the equator at a distance of 22,260 miles approximately. The satellites rotate around the earth in the same direction as the earth and at a speed that makes it appear as though the satellite remains at a fixed location above the earth. This is referred to as geostationary as the pictured to the right shows. Every satellite has an earth station which controls and maintains its position above the earth as well as the direction the satellite faces so its communication beams are not directed to outer space but back to the earth. To put the satellites distance into prospective the International Space Station (ISS) is in Low Earth Orbit (LEO) which is between 100 - 1250 miles above the sea level. The ISS is approximately 250 miles above the earth.

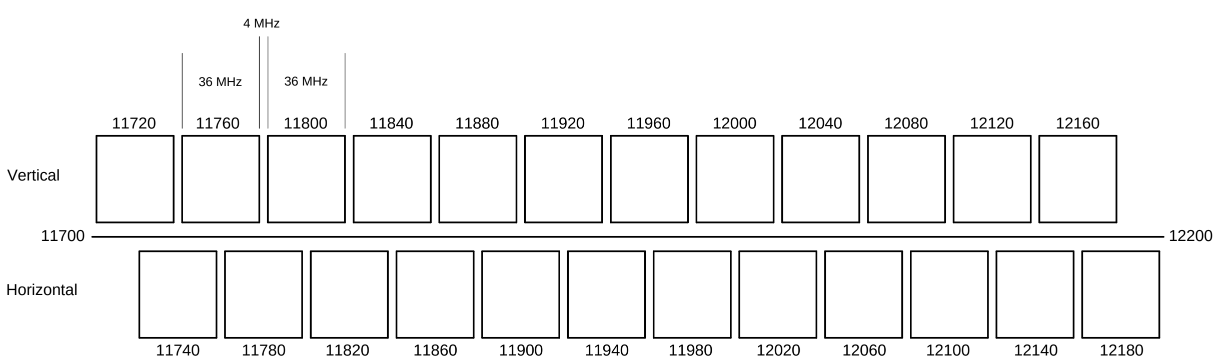


The satellite's earth station keeps it within a specific area so it does not stray and bump into other satellites. In the United States the spacing between satellites is 2 degrees. However, the satellite has a specific amount of bandwidth and when more bandwidth is needed satellites are stacked on top of one another (so close they appear as one satellite from earth) with as little as .25 degrees of separation and positioned slightly north and south of the equator. The picture to the right is of the Clarke Belt and shows stacked satellites. All the satellites have an imaginary box within which it can drift before the earth station will correct its orbit with a short rocket burst. As long as the satellite stays within the box the satellite's communication antenna can receive and re-transmit information.

If you were to stand on the equator, facing south, and looked directly up the Clarke Belt would stretch from the east to the west. Now if you were to walk backwards, still facing south, the Clarke Belt would start to get lower and lower toward the southern horizon. The further north the lower toward the horizon the Clarke Belt would appear. If you could see 22,300 miles you would see the satellites stretch from east to west. And dependent upon the latitude at which you are standing the further north you are the lower toward the horizon the satellites would appear.

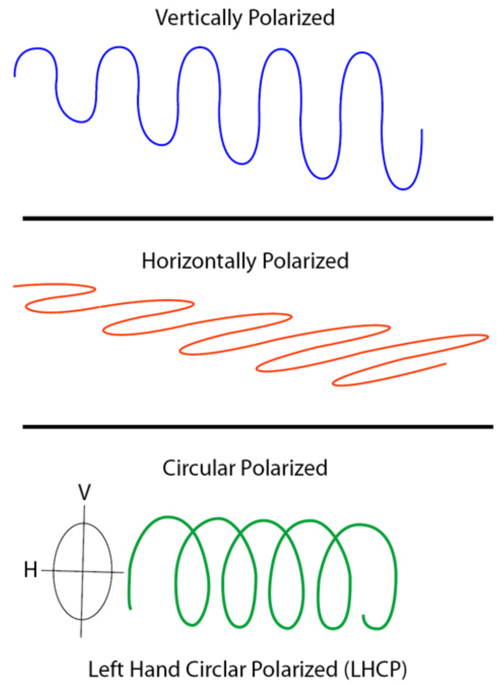
When standing in the northern hemisphere and looking directly southern to the Clarke Belt, the satellite directly south of you will be at the apex of the satellite belt which is running east to west. Looking at the satellites to the left and right of the satellite directly south of you, which is at the apex of the belt, the satellites appears to fall off toward the east and west horizon until they disappear below the horizon. If you move to the east more satellites will start to appear above the horizon but other satellites will appear to disappear below the western horizon as you move away from the west. Although a satellite appears above the horizon, unless the satellite is at least 10 degrees above the horizon, satellite reception is unlikely because of obstruction and / or ground clutter. The higher the satellite is in the sky, closer to the apex, the less likelihood of signal obstruction or ground clutter.

Basically, a satellite has 500 MHz of bandwidth which is divided up into groups of 40 MHz bandwidth of which 36 MHz is usable. These groups are called transponders and the 4 MHz left over of the 40 MHz is to allow 2 MHz each side of the 36 MHz bandwidth for no transmission signal. When two transponders transmitting on the same polarity are sitting next to each other their 2 MHz of "no signal" combine together for 4 MHZ between the high frequency end of one transponder and the low frequency end of the adjacent transponder. 12 transponders with 40 MHz per transponder occupies 480 MHz of the 500 MHZ attributed to the satellite. The 480 MHz is reutilized by shifting the polarity of the signal 90 degrees. The electrical separation of the fields provide 20 - 40db of isolation which is enough to discriminate between the different polarities in the receiver. The results is the re-utilization of the 480 MHz by the opposite polarity. The following satellite frequency plan shows how the satellite's downlink frequency plan is re-utilized to double the transponders by using polarity and shifting the carrier frequency so peak energy is not coinciding with the opposite polarity transponder.

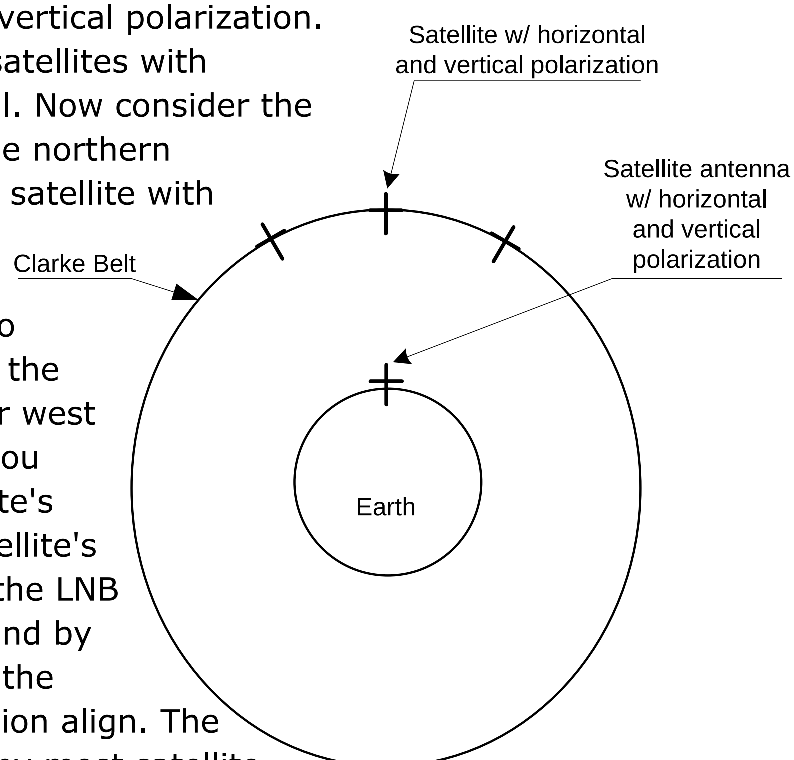


As depict in the diagram above linear polarity is identified as vertical (V) and horizontal (H) and are separated in the electrical field by 90 degrees. Matching the earth station or home satellite antenna's LNB to the correct polarity is critical to receiving signal lock and receiving a good signal from the satellite.

Linear polarity is not the only polarity used on satellites. Circular polarity is another form of polar shifting the satellite frequency for frequency re-utilization. Where linear polarity is vertical and horizontal, circular polarity is left hand circular polarized (LHCP) and right hand circular polarized (RHCP). RHCP rotates in the opposite direction of the LHCP shown in the diagram to the right.



The main benefit of circular over linear is the home satellite user does not have to consider skew for the LNB since the circular polarized signal is constantly rotating. When setting circular polarization set the feed for a left or right hand feed by positioning the center baffle as shown to the left. For the opposite polarity rotate the baffle 90 degrees.



For a better understanding of LNB skew please refer to the diagram to the right which shows the earth with a satellite antenna that has horizontal and vertical polarization. In addition, the Clarke Belt shows three satellites with horizontal and vertical polarization as well. Now consider the earth satellite antenna to be located in the northern hemisphere pointing directly south to the satellite with the same polarization. In this situation the polarization signal of the satellite and the earth antenna align, and therefore, no skew adjustment is required. However, if the satellite you want to view is either east or west of directly south of your antenna, when you point the antenna east or west the satellite's polarization is skewed because of the satellite's orbital arc. To compensate for this skew the LNB is offset (skewed) in the same direction and by the same degree as the satellite skew so the polarization of the satellite and earth station align. The amount of "offset" or "skew" is provided by most satellite aiming programs when you enter your longitude and latitude and the desired satellite's geosynchronous location. The effect of NOT adjusting for skew when it is necessary is for the LNB to pick up both some vertical and some horizontal frequency. This causes interference with the signal you do want as well as reduced the signal strength because you are not accurately aligned with your polarized transponder. To receive maximum signal strength the transponder on the satellite and on your antenna must match. As stated earlier the vertical and horizontal transmission is separated by 90 degrees so they don't interfere with one another. If your LNB is not aligned to maintain the 90 degree separation you will pick up the other polarity and cause interference to your desired signal.

To effectively establish satellite communications an earth station, or home user, will have to know the satellite's location (geosynchronous location), the frequency of the downlink signal, and the polarity (polarization) of the signal. This information along with the earth station's own latitude and longitude is used to provide the azimuth, elevation and skew information necessary for satellite antenna alignment.